DISCUSSION

H. J. Leak (*Member*): There is certainly interest on the part of many engineers (witness the attendance here) in evolving drawings which will give a clearer and quicker understanding of the functioning of the circuit to the reader. At the same time, there appears to be much conservatism among electronic engineers as to the manner in which circuit diagrams are presented, if one judges from the general similarity of published diagrams. I must admit that though I knew of Mr. Bainbridge-Bell's interest in the subject, it was not until he redrew one of my own circuit diagrams, Fig. A, that the logic of his methods was brought home to me. You will see that in Mr. Bainbridge-Bell's drawing, Fig. B, it is immediately apparent that the amplifier consists of a feedback pair and that the switching arrangements allow for frequency-selective feedback. I therefore suggest from my experience that every engineer makes a trial by redrawing one of his own circuit diagrams using the guiding principles expounded by Mr. Bainbridge-Bell, and I feel sure that in the great majority of cases a convert will be made.

(*see overleaf*)

P. I. Nicholson (*Associate Member*): From time to time sets of stencils of electrical symbols have been made, and with them the production of a single file copy diagram of the stencil for a rotary duplicator is made much easier. However, the production of drawings for reproduction by line blocks requires that they should present a much more "finished" appearance than is achieved by such methods. In general, since the final drawing is adjacent to type which is made and aligned with mechanical precision, any imperfection in the drawing tends to be exaggerated.

To this end it is usual to draw diagrams double the size that they will be when printed, and then to reduce them optically in producing the block. By this means a much sharper picture is obtained than would be possible if the original drawing were made the finished size.

This reduction has the additional advantage of making any slight drawing errors in the original almost invisible in the final print. It must not be overlooked that the thickness of the lines in a drawing is also reduced in proportion to the overall reduction. Allowance should be made for this when drawing circuit diagrams for block making.

Production of uniform symbols in circuit diagrams is considerably facilitated by the use of the standard symbols printed on gummed paper. First, the necessary symbols are cut out and then put in position on a sheet of blue-line $\frac{1}{4}$-in squared paper, the squares providing excellent guides. Symbols (if they are not immediately stuck down) can be moved about freely (for this a pair of tweezers is useful) to ensure a good lay-out.

Having secured all the symbols to the blue-lined squared paper and lightly pencilled in the interconnecting lines, the "contact dots" are inked in, using either ink compasses or a suitable stencil. The right-angle bends are then "rounded," vertical, horizontal and oblique lines are inked in, and the drawing is complete apart from any lettering, arrowheads, etc., which may be required. An example is given in Fig. C (half size) in which the blue lines of the squared paper are represented by dotted lines.

In order to ensure that any titles are centrally placed where required, it is only necessary to

(*contd. on p. 349*)

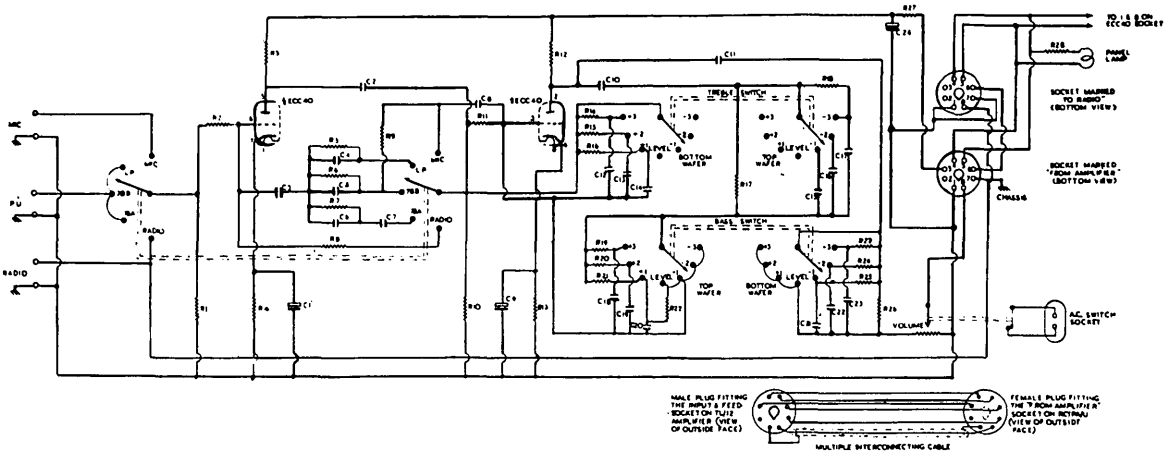

Fig. A.—Circuit of an R-C coupled audio-frequency pre-amplifier. (See contribution by H. J. Leak.)

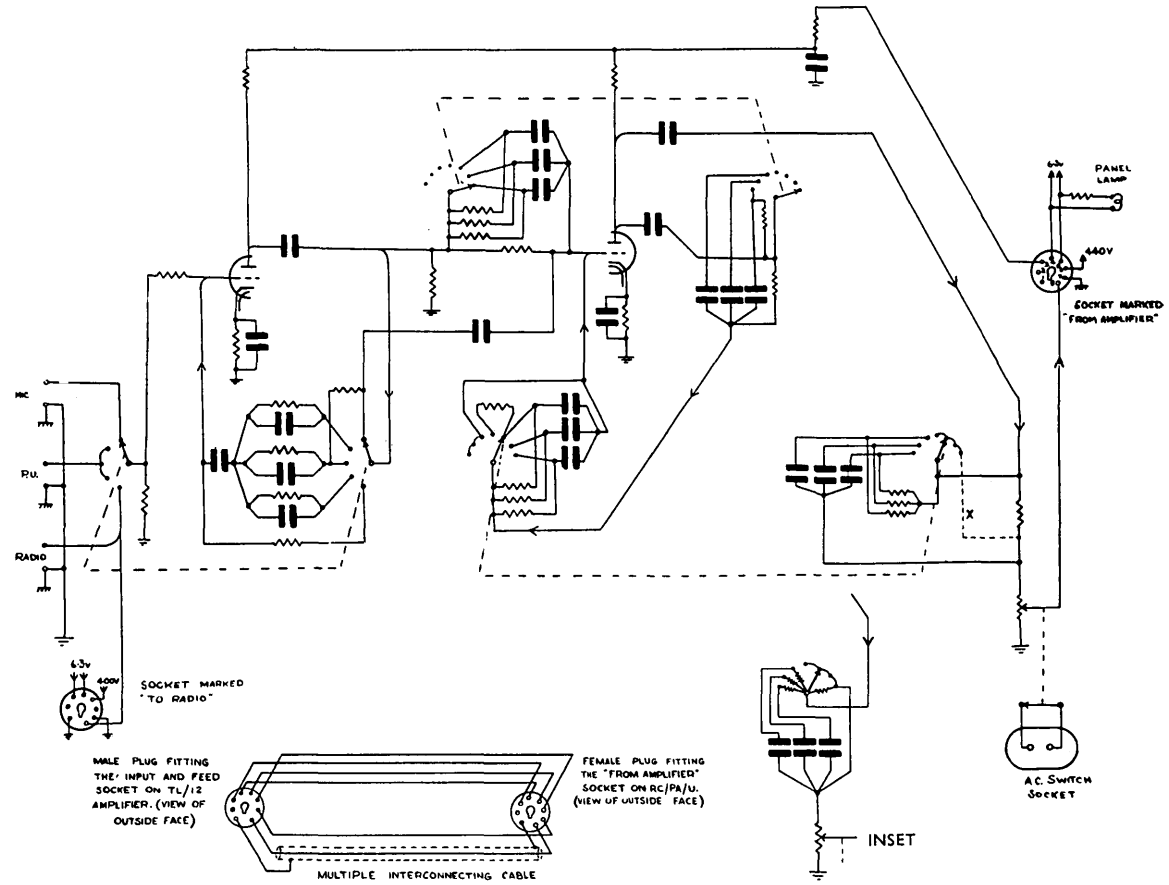

Fig. B.—Circuit of Fig. A redrawn by Mr. Bainbridge-Bell.

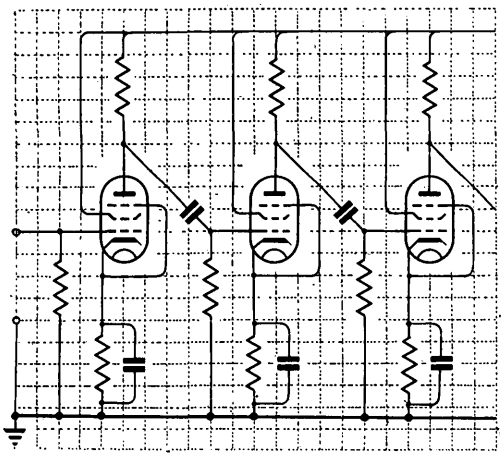

Fig. C.

draw them on white gummed paper which can then be cut and correctly fixed with ease.

Should any mistakes have been made in the inking-in process it is not necessary laboriously to erase them. Artist's "process white" poster paint readily covers them up and can be inked over when dry. In the block-making this paint will be quite invisible, as will be the blue lines of the squared paper, a suitable filter in front of the camera preventing their being reproduced. This is the reason why blue-lined paper has been specified, no other colour being entirely satisfactory. Fig. D is a print from the finished block made from the original of Fig. C.

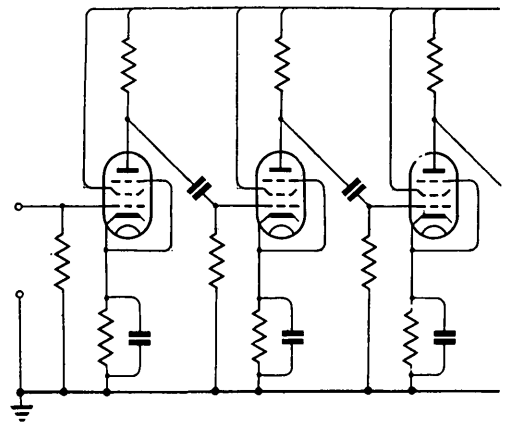

Fig. D.

In preparing a circuit diagram on tracing paper to be reproduced by one of the usual drawing office systems, it is necessary first to produce an original for subsequent tracing. In this case the squared paper need not necessarily be blue-lined, but the "stickers" will be slightly different (Fig. E) in that they must give construction lines and centres to aid the tracer.

Having obtained a satisfactory lay-out, stuck down the symbols and roughly pencilled in the interconnecting lines, tracing paper or cloth is placed over the squared paper and the whole drawing traced. Prints are then taken from the finished drawing.

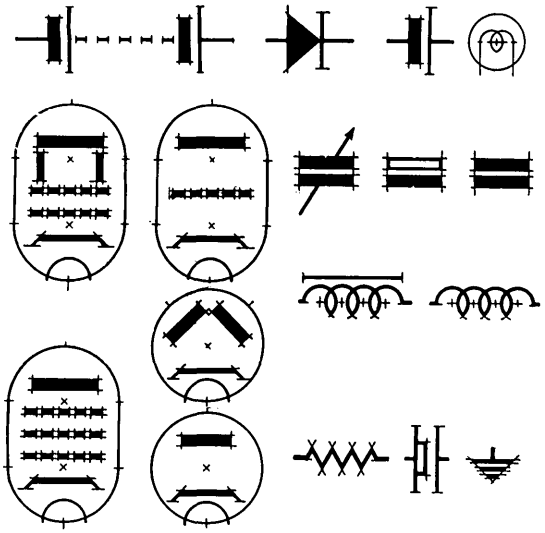

Fig. E.

I. A. Harris (*Associate Member*): Mr. Bainbridge-Bell's suggestion of curving certain branches at their junctions with a main lead appeals to me very much. I agree that such an arrangement tends to lead the eye direct to a source or other part of the diagram.

The method of drawing circuit diagrams generally adopted in this country appears to give precedence in clarity to the d.c. valve supplies, a method which sometimes subordinates the signal circuits to the point at which their operation is difficult to follow. Since the purpose of a circuit diagram is to facilitate understanding the operation of a piece of equipment, it seems to me to be more logical to emphasize the signal circuits and to subordinate the d.c. supplies.

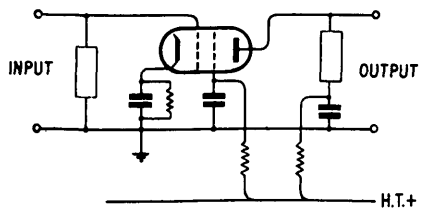

Fig. F.

Thus Fig. F shows an ordinary tetrode amplifier in which the signal circuits are given as direct a path as possible, being broken only by d.c.-blocking capacitors. The cathode bias resistor is drawn to one side because here it is mainly a d.c. path. If both capacitor and resistor take part in the signal amplification (i.e. partial selective feedback) they would be drawn symmetrically in the preferred fashion. The valve is drawn on its side to emphasize the grounding of the screen grid and its shielding of the control grid from the anode. H.T. supplies can be taken either above or below the "earth" line. The rectangles would, in practice, be replaced by the details of the particular input or output circuits actually used.

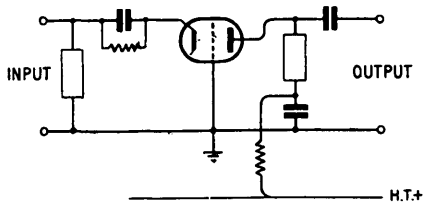

Fig. G.

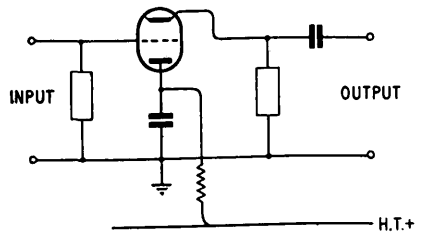

Fig. H.

Figures G and H show the proposed form of circuits for grounded-grid and cathode-follower amplifiers, respectively. Again, the functioning is emphasized at the expense of departing from the present custom.

J. L. Thompson (*Member*): Mr. Bainbridge-Bell has said that you must know your circuit before you can draw the diagram. But draughtsmen in the drawing office do not necessarily know the circuit, but merely copy the scrappy detail information given them by the engineer. The engineer is obviously the right person to draw the circuit diagram because only he really knows the information he is trying to put over. Circuit diagram drawing is a very long job and is really only the record of history whereas an engineer usually much prefers to write the future.

The use of 1-in. squared paper for diagram drawing and the subsequent photographing of this through a filter (to remove the lines) has been found a help and we, as a company, are giving some attention to using the magnetic lines and symbols for producing a circuit diagram which can then be photographed and printed off.

M. G. Scroggie: I would like to refer to the time-wasting and irritating practice of specifying the values of components in a circuit diagram as a separate list. Admittedly it may be difficult to show the values clearly on the diagram itself if, for example, each capacitor has to be accompanied by a legend such as "C.26 : 0·001 μF." But this objection is largely removed by following the example of the Services and omitting, F, H, and Ω (for these basic units are sufficiently indicated by the component symbol), and, in the case of capacitors, following Continental practice by making use of the subdivision "nano-," denoted by n, meaning 10^{-9}. The most-used values of capacitance are of the order of 1nF, and the advantages of replacing "0·001 μF" or "1,000 pF" by "1n" are manifest. Moreover, the use of p and n where appropriate greatly reduces the number of occasions requiring the Greek symbol μ.

The symbol for a cathode ray tube specified in B.S.530 (Fig. J(1)) is suitable for use in circuit diagrams of oscilloscopes, but such diagrams are likely to be greatly out-numbered by those illustrating applications of cathode ray tubes, for which the symbol shown in Fig. J(2) is much simpler and more convenient. The centre spot denoted the final anode, usually earthed.

In circuit diagrams of measuring instruments, etc., it is often necessary to show components varied by stud switches. A great simplification

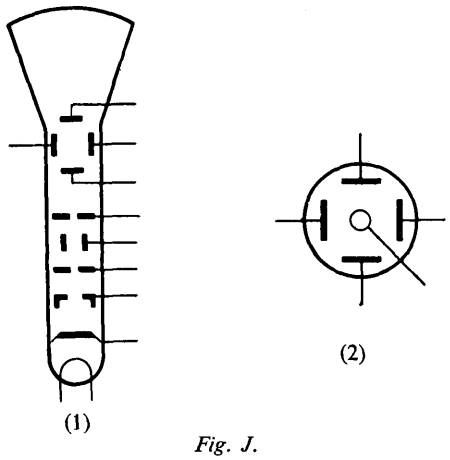

Fig. J.

can be effected by replacing the usual elaborate diagram of a stud switch and associated resistors, etc., by the modified variability symbol shown in Fig. K. The number of positions can be indicated as suggested, or alternatively the actual values available can be shown.

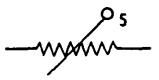

Fig. K.

There is a growing need for a symbol denoting a constant-current generator. Since its internal impedance, if finite, is regarded as being in parallel, the symbol for a voltage generator, assumed to have zero internal impedance, is inappropriate, as it suggests a short-circuit where none exists. The alternative of an open circuit with a current arrow looks untidy. Are there any suggestions?

G. May (*Associate*): Mr. Bainbridge-Bell's survey enabled the radio engineer to obtain some idea of what happened behind the doors of the B.S.I. and of the hard work that goes into the production of a British Standard.

As the development of a project proceeds, the engineer keeps adding units to his circuit diagram. Consequently, when the circuit diagram reaches the drawing office, one cannot readily trace the signal path. Therefore a block diagram should be prepared before any attempt is made to draw the circuit diagram.

I think we should have more block symbols, e.g. limiter, reactance, valve, discriminator. Mr. Bainbridge-Bell objects, but I have good reasons for asking for these. If you want to draw a block diagram quickly for use in discussions it is easier to draw symbols. If more block symbols were available we should be able to understand a circuit as given in a foreign journal without the need to know the language. Not all publications that are of interest to radio engineers are available in English. Furthermore, the eye and the brain take in symbols faster than words. I feel, too, that the "Grammar" section of symbols does need extending. Thus we should have standard forms of the Colpitts and Hartley circuits, Foster-Seeley discriminator, etc.

It would appear, presumably on economic grounds, that some firms try to use the theoretical diagram as a wiring diagram. This leads to a poor theoretical diagram.

I think it would be very helpful if we could get the component manufacturers to use the same system as given in para. 36 of B.S. 530 : 1948. Thus, up to 999 pF we would use pF and not μF, e.g. 100 pF not 0·0001 μF. This applies particularly in the case of "Service" equipment, for if this system was followed the "Service" man would need to remember one system and one system only, and it would be the same system as used on the circuit diagram.

The terms Tera, Giga, and Nano are already in use in "Symbols Signs and Abbreviations," a report by the Symbols Committee of the Royal Society, published in 1951.

Dr. G. L. Hamburger (*Member*): I have noticed with amazement that the small k laid down to denote kilo can still represent a subject of discussion in this country. A previous speaker even wanted to have the small k changed into a capital K. Quite apart from the fact that the small k (denoting kilo) has been established for probably more than 100 years in all countries using the metric system in such units as, for instance, kilometres (km) and kilogrammes (kg), there is a very simple rule laying down the priority in which letters may be used.

(1) Small Roman letter symbols to be used for all units and multiplying and dividing factors.

(2) Only when small symbols have been exhausted are capital symbols to be used to avoid ambiguity.

(3) Capital symbols to be exclusively for units named after men, such as capital H for Henry, capital F for Farad.

It is only when the small letters are exhausted that capital letters are being used. The small m denoting either metre or milli can, of course, not likewise be used for mega, and for this reason only, a capital M is used for mega, and not only because it is a multiplying factor. Hektolitre, namely 100 litres, is symbolized by small h small l (hl) although Hekto stands for a multiplying factor. There is therefore no shadow of a doubt that kilo should always be denoted by a small k.

There is, however, another point to which I should like to refer in this connection, and that is the most peculiar habit of adding the plural s to units. Apart from the fact that it is completely unnecessary to do so, this habit is, of course, entirely inconsistent. Nobody would dream of writing £5 as £s5, yet everybody writes five pounds in weight as 5 lbs., or if people venture into the metric system, and want to write 5 grammes, they invariably put it as 5 gms, which any serious physicist would, of course, read as 5 gramme-metre-seconds.

Finally, I should like to say that the wrong use of symbols cannot possibly be interpreted or excused by "the freedom of the individual." To my mind, it can only be put in the same category as wrong spelling. The argument that everybody in his senses will interpret "5 mc" as 5 megacycles per second and not 5 millicycles is just not good enough.

E. A. W. Spreadbury (*Member*): Mr. Nicholson is to be congratulated on his method of using printed symbols to stick on to square paper. We are publishers, and use our drawings only for block-making. This method has been used for many years, and has been found very satisfactory, so long as a reliable adhesive is used, but we have recently abandoned the scheme in favour of Uno stencils.

Instead of using the triangle and single-turn coil stencil for a resistor or coil as suggested by Mr. Bainbridge-Bell, we showed the makers what we wanted and asked them for a solution. They supplied us with a continuous ziz-zag slot for resistors, of ample length for any need. For coils, they provide a series of ellipses lined up in a row, and a row of scolloped loops to join them.

I would like to suggest to the meeting that there is an urgent need for a recognized symbol for a permanent magnet. These are used for various purposes in modern television receivers, and, although we have introduced symbols to represent them, it is desirable that they should be standardized.

A recommendation which has been adopted, consisting of a rectangle marked "N" and "S", still leaves annular magnets and disc or ring magnets to be catered for. These are, of course, used for focus and shift controls.